'Dempsey', a Virus- and Bacterial Spot-Resistant Bell Pepper

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Several viruses and bacterial spot, caused by *Xanthomonas campestris* pv. *vesicatoria* (Doidge) Dye, are the most serious diseases of pepper (*Capsicum annuum* L.) in many areas of the United States. Historically, tobacco etch virus (TEV) and bacterial spot, often in combination, have been limiting factors in commercial pepper production in the mountainous regions of northeastern Georgia (Benner et al., 1985). In 1981, Dempsey et al. (1981) released a breeding line designated as 'C44' that was described as a four-way cross, open-pollinated field selection with field resistance to both bacterial spot and TEV. Sowell (1960) found bacterial spot resistance in several plant introductions from India, including PI 163192. Cook and Stall (1963) confirmed this resistance and reported that it was due to a single, dominant gene.

In a series of field tests beginning in 1986 at Blairsville, Ga., we found that several pepper lines with 'C44' parentage had a higher level of resistance to indigenous strains of TEV and the bacterial spot pathogen than numerous other lines under heavy disease pressure. In the presence of severe bacterial spot epidemics, these lines produced relatively high yields and had a low disease level without bactericidal sprays (McCarter, 1992). These observations led to a breeding program that resulted in the development of 'Dempsey'. The cultivar was named to honor the late A. Hugh Dempsey, who not only identified the sources of resistance used in the breeding program but who also contributed significantly to other pepper breeding efforts.

Origin

'Dempsey' was tested as GA 89-3-1. It originated from a three-way cross between PI 163192, PI 264281, and 'Jupiter'. These two

plant introductions were used because they contributed disease-resistant genes in 'C44'. 'Jupiter' was used as the recurrent parent for three generations, followed by selfing for two generations (Fig. 1).

Progeny in each generation were selected in a disease screening program under greenhouse and field conditions. In the greenhouse, bacterial spot evaluations were conducted after incubation of plants for 2 d in a mist chamber to provide conditions conducive for disease development. Heavy disease pressure was established in the field by transplanting susceptible plants within rows of progeny being screened and by later inoculating the susceptible plants with TEV and the bacterial spot pathogen. Selections were made for disease-resistant plants with excellent horticultural characteristics, which included plant type, yield, and fruit quality.

Description and performance

Mature plants of 'Dempsey' range in height from 56 to 76 cm, with an average of 64 cm (Table 1). Fruits mature in ~60 days following transplanting. They are nonpungent, three- or four-lobed, and have a shape typical of bell types. Mature fruits averaged 9.5 cm in length, 6.9 cm in diameter, and 141 g of fruit mass. Fruit wall thickness averaged 5.7 mm.

Fruit yields have been consistently high under heavy disease pressure. Replicated yield tests were conducted in 1994 at Athens, Blairsville, and Plains, Ga., to compare 'Dempsey' with two standard cultivars. At Plains, where TEV did not occur, and only a low incidence of bacterial spot was present, the yield of 'Dempsey' was similar to that obtained from 'Yolo Wonder' and 'Jupiter'. At Athens, where TEV was not present, but a severe natural outbreak of bacterial spot occurred, 'Dempsey' yielded nearly three times as much as 'Jupiter' and more than five times as much as 'Yolo Wonder'. Even greater yield differences were recorded at Blairsville where inocula were intentionally introduced, and both diseases reached epidemic proportions. Similar yield responses occurred in other tests conducted at Blairsville during 1994 and 1995 when one or both diseases were present (Tables 2 and 3).

Disease resistance

In field tests 'Dempsey' has remained free of all strains of TEV indigenous to Georgia, regardless of whether inoculum was spread by aphids from naturally occurring or intentionally introduced source plants or whether plants were mechanically inoculated (by rubbing) with a suspension having a high virus titer (Table 3). In greenhouse and laboratory tests no replication of the virus was detected in mechanically inoculated leaves, which indicates that 'Dempsey' is immune to TEV. In other greenhouse and field tests at Athens, 'Dempsey' also was immune to pepper mottle virus (PepMoV). In the greenhouse, all 20 'Dempsey' plants inoculated mechanically remained free of PepMoV as determined by symptomatology and ELISA (Converse and Martin, 1990), whereas all 20 'Jupiter' plants inoculated similarly showed severe symptoms and tested positive. In 1995 field tests at Athens, 30 of 30 'Dempsey' plants inoculated mechanically remained free of the virus as determined by ELISA tests, whereas all 30 inoculated 'Jupiter' plants were severely dis-

Fig. 1. Pedigree of 'Dempsey' bell pepper.

Table 1. Plant and fruit characteristics of 'Dempsey' bell pepper compared with two standard cultivars grown at Blairsville, Ga., in 1995.

Cultivar	Fruit characteristics (means)						
	Plant ht. (cm)	Canopy width (cm)	Mass (g)	Length (cm)	Width (cm)	Core mass (g)	Wall thickness (mm)
Yolo Wonder	83 a ²	72 a	133.0 a	8.6 a	6.9 a	20.2 a	5.2 a
Jupiter	68 b	60 b	133.6 a	8.2 a	7.3 a	20.3 a	5.3 a
Dempsey	64 b	57 b	141.1 a	9.5 a	6.9 a	19.4 a	5.7 a

²Mean separation within each column by Duncan's multiple range test at $P \leq 0.05$.

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Table 2. Yield and disease reaction of 'Dempsey' bell pepper compared with other standard cultivars in the presence of three races of the bacterial spot pathogen in widely separated plots at Blairsville, Ga., in 1994.

Genotype	Bacterial spot race introduced ²				
	1		2		3 ³
	Yield ⁴ (mean kg/plot)	Disease rating ⁵	Yield (mean kg/plot)	Disease rating	Disease rating
Yolo Wonder B	5.67 a ⁶	4.6 a	7.44 a	4.4 a	3.2 a
Jupiter	7.10 a	4.1 b	11.84 b	3.8 b	2.8 b
Dempsey	19.56 b	0.7 c	29.62 c	0.2 c	0.2 c

²The races of the bacterial spot pathogen were introduced by inoculating two Yolo Wonder plants in each row 4 weeks after transplanting.

³No yield data were collected from this plot as the plot was located near a stream and was flooded about midseason. Plants were rated for disease prior to the flooded conditions.

⁴Based on six harvests of mature green marketable fruit. Each value is a mean of five replications consisting of a single row with 26 plants spaced 30 cm apart.

⁵Disease was rated on a 0 to 5 scale where 0 = no disease, 1 = isolated lesions with no defoliation, 5 = numerous large and rapidly expanding lesions with severe defoliation.

⁶Mean separation within each column by Duncan's multiple range test at $P \leq 0.05$.

Table 3. Yield and disease reaction of 'Dempsey' compared with 'Jupiter' at two locations in Georgia in 1995.

Genotype	TEV treatment ²	Location					
		Athens			Blairsville		
		Yield (mean kg/plot) ⁴	Disease reaction ⁵		Yield (mean kg/plot)	Disease reaction ⁵	
Jupiter	None	9.33 a ⁶	Bacterial spot ⁷	TEV (%) ⁸	1.50 a	Bacterial spot	TEV (%)
Jupiter	Inoculated	5.82 b	3.9 a	100	0.11 b	4.1 a	100
Dempsey	None	20.92 c	4.4 b	100	7.52 c	4.5 b	100
Dempsey	Inoculated	20.17 c	T	0	6.56 c	T	0

²TEV and the bacterial spot pathogen (race 1) were intentionally introduced at Blairsville by inoculating two Yolo Wonder plants in each row 3 (TEV) and 4 (bacterial spot) weeks after transplanting. The bacterial spot at Athens resulted from a natural outbreak.

³All plants were either left noninoculated or were inoculated by rubbing with a tobacco etch virus (TEV) suspension 3 weeks after transplanting.

⁴Based on 10 (Athens) or four (Blairsville) harvests of mature green fruit. Each value is a mean of five replications consisting of a single row with 26–28 plants spaced 30 cm apart.

⁵Bacterial spot was rated on a 0 to 5 scale where 0 = no disease, 1 = isolated lesions with no defoliation, 5 = numerous large and rapidly expanding lesions with severe defoliation, and T = trace (occasional lesions). Ratings were made at midseason.

⁶All inoculated 'Jupiter' plants showed typical TEV symptoms within 2 weeks after inoculation, and symptoms progressed during the growing seasons. Many of the noninoculated plants became infected during the season from natural spread. No symptoms of TEV were observed on 'Dempsey'. Values shown represent the percentage of plants that gave positive ELISA readings (Converse and Martin, 1990). Sample sizes were 20 and 100 plants for the noninoculated and inoculated 'Dempsey', respectively, and 20 and 20 plants for the noninoculated and inoculated 'Jupiter', respectively.

⁷Mean separation within each column by Duncan's multiple range test at $P \leq 0.05$.

eased and tested positive. In recent greenhouse tests, 'Dempsey' also was highly resistant or immune to strains of potato virus Y (PVY). As TEV, PepMoV, and PVY are all potyviruses, it is possible that 'Dempsey' has general resistance to this entire group of viruses.

In field tests at Blairsville, 'Dempsey' has shown excellent field resistance to races 1, 2, and 3 of the bacterial spot pathogen (Table 2). It also has held up well to naturally occurring strains and races of the pathogen that have appeared at Athens and Blairsville during the last 4 years.

Availability

Management of release and distribution of seed is through the Georgia Seed Development Commission, 24020 South Milledge Avenue, Athens, GA 30605.

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